Triple Band Microstrip Antenna with Defected Ground Plane

A THESIS SUBMITTED IN PARTIAL REQUIREMENTS
FOR THE DEGREE OF
BACHELOR OF TECHNOLOGY
IN
ELECTRONICS & INSTRUMENTATION ENGINEERING
By

HEROJIT NINGTHOUJAM

107EI001

Under the Guidance of

Prof. S K Behera

Department of Electronics & Communication Engineering
National Institute of Technology, Rourkela
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CERTIFICATE

This is to certify that the thesis entitled "Triple Band Microstrip Patch Antenna With Defected Ground Plane" submitted by Sri Herojit Ningthoujam in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Electronics and Instrumentation Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

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Last but not least I would like to thank all my friends and well wishers who were involved directly or indirectly in successful completion of the present work.

Herojit Ningthoujam
107EI001

Contents

Abstract

In this rapid changing world in wireless communication systems, multiband antenna has been playing a very important role for wireless service requirements. Wireless local area network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) have been widely applied in mobile devices such as handheld computers and intelligent phones. These two techniques have been widely considered as a cost-effective, viable, and high-speed data connectivity solution, enabling user mobility.

The thesis proposed a compact triple-band microstrip slot antenna applied to WLAN/WiMAX applications. This antenna has a simpler structure than other antennas designed for realizing triple-band characteristics which is just composed of a microstrip feed line, a substrate, and a ground plane on which some simple slots are etched.

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Chapter 1

Thesis Overview

1.1 Introduction

In modern wireless communication systems, multiband antenna has been playing a very important role for wireless service requirements. Wireless local area network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) have been widely applied in mobile devices such as hand held computers and intelligent phones. These two techniques have been widely recognized as a viable, cost-effective, and high-speed data connectivity solution, enabling user mobility With the rapid development of the modern wireless communication system, antenna design has turned to focus on wide multiband and small simple structures that can be easy to fabricate. To adapt to the complicated and diverse WLAN and WiMAX environments.

1.2 Aim and Objective

The aim of my project is to design a microstrip patch antenna giving triple band performance using defected ground plane. In the last few years many people have proposed different types of microstrip antenna but this antenna is very compact comparing to other microstrip patch antenna.

1.3 Thesis outline

Chapter 2: This chapter presents the basic theory of MPAs, including the basic structures, feeding techniques and characteristics of the MPA. Then the advantages and disadvantages of the antenna are discussed and the methods of analysis used for the MPA design

Chapter 3: In this chapter the basics of antenna parameters such as radiation pattern, impedance, VSWR, gain etc. are presented.

Chapter 4: This chapter describes the design of Triple Band Microstrip Antenna. The simulation result for this antenna has been discussed. Then the performance of the antenna has been studied by comparing return loss, radiation pattern, VSWR, gain, bandwidth and axial ratio.

Chapter 5: This chapter contains conclusion and scope of future work.

Chapter 2

Microstrip Antenna

Microstrip Antenna

2.1 Introduction

A microstrip antenna generally consists of a dielectric substrate sandwiched between a radiating patch on the top and a ground plane on the other side as shown in Figure 2.1. The patch is mainly made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

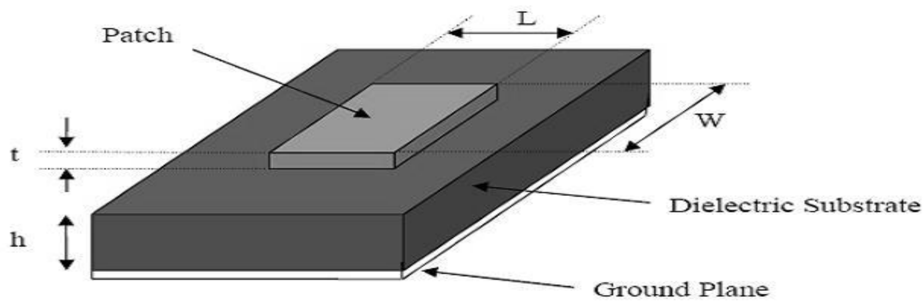


Figure 2.1 Structure of a Microstrip Patch Antenna

Figure 2.1 Structure of a Microstrip Patch Antenna

For simplicity of analysis, the patch is mainly square, rectangular, circular, triangular, and elliptical or some other usual shape. For a rectangular patch, the length *L* of the patch is mainly in the range of $0.3333\ \lambda0 < L < 0.5\ \lambda0$, where $\lambda0$ is the free space wavelength. The patch in which I am considering is to be very thin such that $t \ll \lambda o$ (where *t* is the patch thickness). The height *h* of the dielectric substrate is usually $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$. The dielectric constant of the substrate (εr) is typically in the range $2.2 \leq \varepsilon r \leq 12$.

2.2 Advantages and Disadvantages

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are highly compatible for embedded antennas in handheld wireless devices such as pagers, cellular phones etc... The telemetry and communication antennas on missiles need to be thin and conformal and are often in the form of Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. Some of their main principal advantages are given below:

- Light weight and low volume.
- Low fabrication cost, thus it can be manufactured in large quantities.
- Supports both, linear as well as circular polarization
- Can be easily combine with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of the major disadvantages are given below:

- Narrow bandwidth.
- Low efficiency.
- Low Gain.
- Poor end fire radiator except tapered slot antennas.
- Low power handling capacity.
- Surface wave excitation.
- Extraneous radiation from feeds and junctions.

2.3 Feed Techniques

There are different techniques available to feed or transmit electromagnetic energy to a microstrip antenna. The four most popular feeding methods are the Microstrip line, coaxial probe, aperture coupling and proximity coupling.

2.3.1 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 2.2, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

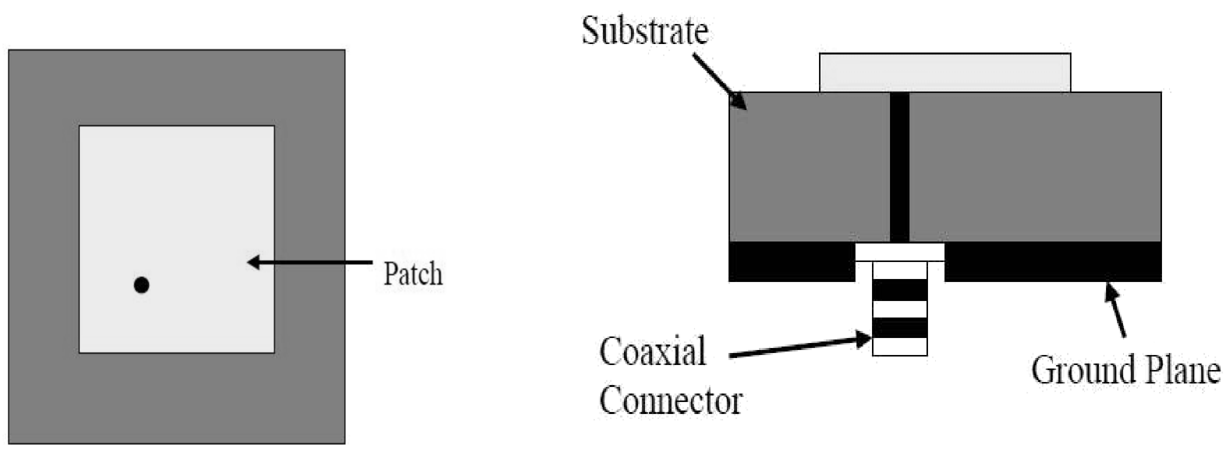


Figure 2.2 Rectangular Microstrip antenna coaxial feed

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, a major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda_o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. The non-contacting feed techniques which have been discussed below, solve these issues.

2.3.2 Microstrip Feed line

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Figure 2.3. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna [1]. The feed radiation also leads to undesired cross polarized radiation.

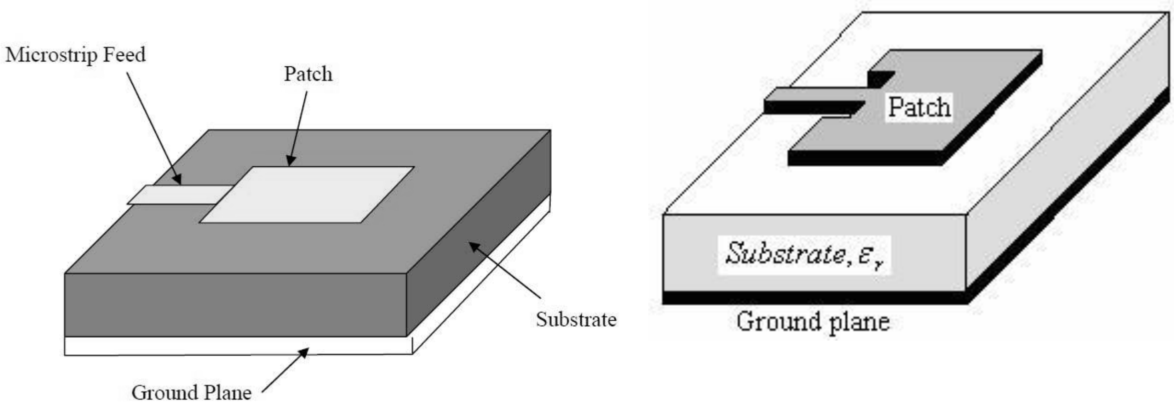


Figure 2.3 Rectangular Microstrip antenna Microstrip Line feeding

2.3.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the Microstrip feed line are separated by the ground plane as shown in Figure 2.4. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch [1]. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth (up to 21%).

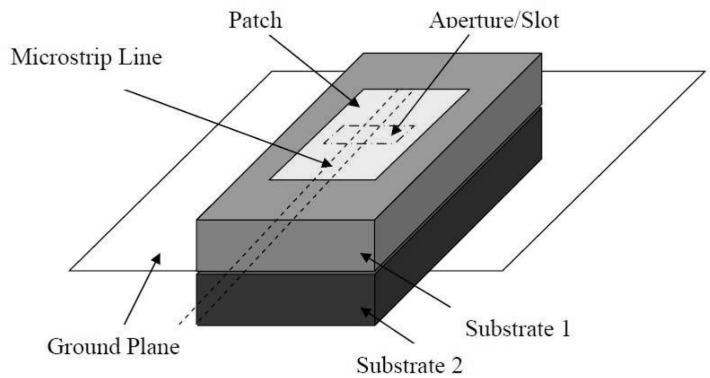


Figure 2.4 Rectangular Microstrip antenna Aperture coupled feed

2.3.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Figure 2.5, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.

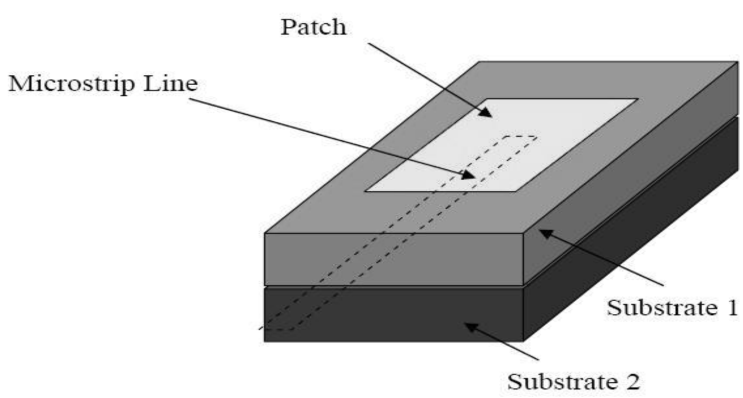


Figure 2.5 Proximity-coupled Feed

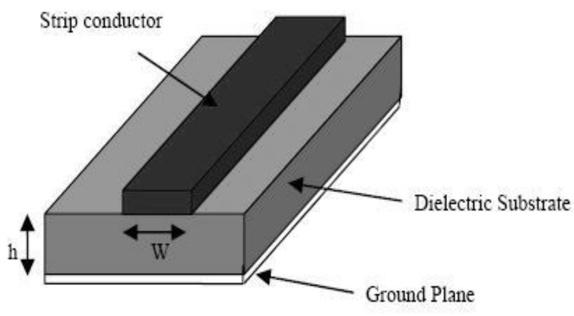
Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna.

2.4 Methods of Analysis

The preferred models for the analysis of Microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight but it is less accurate. The cavity model is more accurate and gives good physical insight but is complex in nature. The full wave models are extremely accurate, versatile and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements and coupling. These give less insight as compared to the two models mentioned above and are far more complex in nature.

2.4.1 Transmission Line Model

This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a non-homogeneous line of two dielectrics, typically the substrate and air.



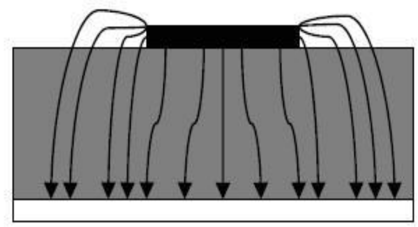


Figure 2.6 Microstrip Line

Figure 2.7 Electric Field Lines

Hence, as seen from Figure 2.7, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant ($\varepsilon reff$) must be obtained in order to account for the fringing and the wave propagation in the line. The value of $\varepsilon reff$ is slightly less then ε_r because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air.

The expression for $\varepsilon reff$ is given by [1] as:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Where $\varepsilon reff$ = Effective dielectric constant

ε_r = Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

Consider Figure 2.8 below, which shows a rectangular microstrip patch antenna of length *L*, width *W* resting on a substrate of height *h*. The co-ordinate axis is selected such that the length is along the x direction, width is along the *y* direction and the height is along the *z* direction.

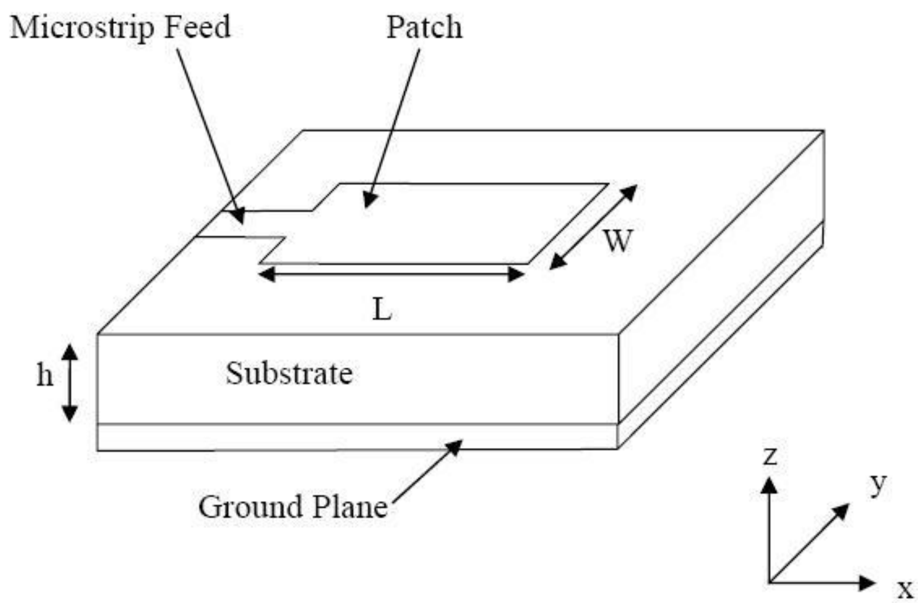
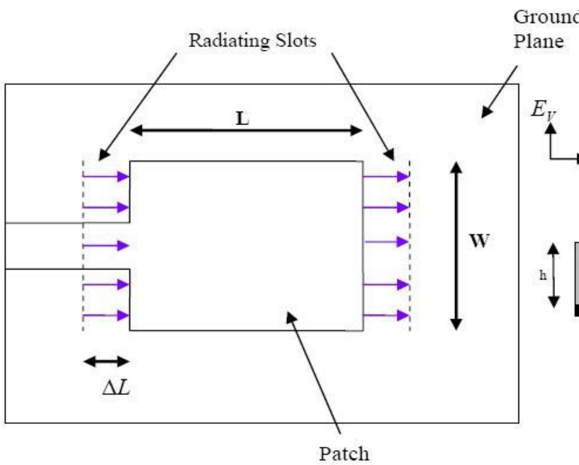


Fig. 2.8 Microstrip Patch Antennas

In order to operate in the fundamental TM_{10} mode, the length of the patch must be slightly less than λ/2 where λ is the wavelength in the dielectric medium and is equal to $\lambda_o/\sqrt{\varepsilon reff}$ where λ_o is the free space wavelength. The TM_{10} mode implies that the field varies one λ/2 cycle along the length, and there is no variation along the width of the patch. In the Figure 2.9 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.



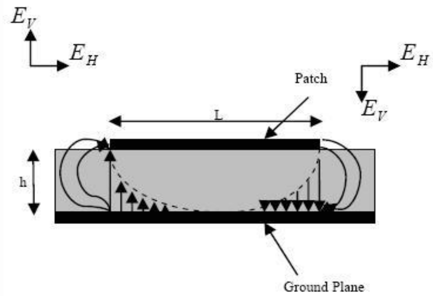


Fig 2.9 Top View of Antenna **Fig. 2.10** side view of antenna

It is seen from Figure 2.10 that the normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase since the patch is $\lambda/2$ long and hence they cancel each other in the broadside direction. The edges along the width can be represented as two radiating slots, which are $\lambda/2$ apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically as:

$$\Delta L = 0.412h \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L$$

For a given resonance frequency f_o, the effective length is given by [9] as:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

For a rectangular Microstrip patch antenna, the resonance frequency for any TM_{mn} mode is given by James and Hall as:

$$f_o = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}}$$

Where m and n are modes along L and W respectively.

For efficient radiation, the width W is given by Bahl and Bhartia [15] as:

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

2.4.2 Cavity Model

The cavity model helps to give insight into the radiation mechanism of an antenna, since it provides a mathematical solution for the electric and magnetic fields of a microstrip antenna. It does so by using a dielectrically loaded cavity to represent the antenna. This technique models the substrate material, but it assumes that the material is truncated at the edges of the patch. The patch and ground plane are represented with perfect electric conductors and the edges of the substrate are modeled with perfectly conducting magnetic walls.

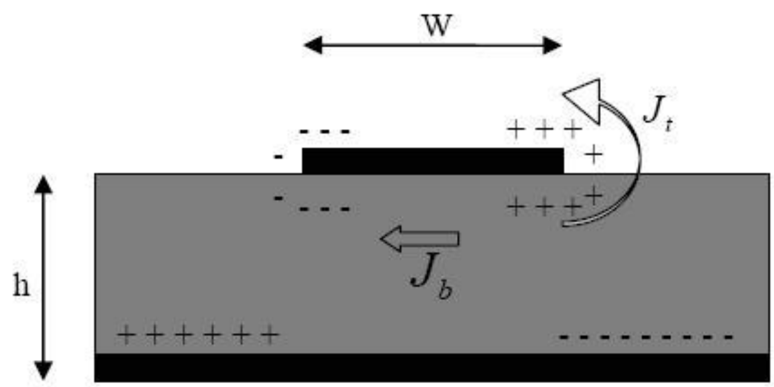


Figure 2.11 Charge distribution and current density creation on the microstrip patch

Consider Figure 2.11 shown above. When the microstrip patch is provided power, a charge distribution is seen on the upper and lower surfaces of the patch and at the bottom of the ground plane. This charge distribution is controlled by two mechanisms ─ an attractive mechanism and a repulsive mechanism. The attractive mechanism is between the opposite charges on the bottom side of the patch and the ground plane, which helps in keeping the charge concentration intact at the bottom of the patch. The repulsive mechanism is between the like charges on the bottom surface of the patch, which causes pushing of some charges from the bottom, to the top of the patch. As a result of this charge movement, currents flow at the top and bottom surface of the patch. The cavity model assumes that the height to width ratio (i.e. height of substrate and width of the patch) is very small and as a result of this the attractive mechanism dominates and causes most of the charge concentration and the current to be below the patch surface. Hence, the four sidewalls could be modeled as perfectly magnetic conducting surfaces. Therefore, we only need to consider TMz modes inside the cavity.

Chapter 3

Antenna Parameters

Performance Parameters

The performance of an antenna can be measured by a number of parameters. The followings are the critical ones.

3.1 Radiation Pattern

The antenna pattern is a graphical representation in three dimensional of the radiation of the antenna as the function of direction. It is a plot of the power radiated from an antenna per unit solid angle which gives the intensity of radiations from the antenna [3]. If the total power radiated by the isotropic antenna is P, then the power is spread over a sphere of radius r, so that the power density S at this distance in any direction is given as:

$$S = \frac{p}{4\pi r^2}$$

Then the radiation intensity for this isotropic antenna Ui can be written as:

$$U_i = \frac{p}{4\pi}$$

Isotropic antennas are not realizable in practice but can be used as a reference to compare the performance of practical antennas. The radiation pattern provides information on the antenna beam width, side lobes and antenna resolution to a large extent.

The E plane pattern is a graphical representation of antenna radiation as a function of direction in a plane containing a radius vector from the centre of the antenna to the point of maximum radiation and the electric field intensity vector. Similarly the H plane pattern can be drawn considering the magnetic field intensity vector

3.2 Gain

Antenna gain is the ratio of maximum radiation intensity at the peak of main beam to the radiation intensity in the same direction which would be produced by an isotropic radiator having the same input power. Isotropic antenna is considered to have a gain of unity. The gain function can be described as:

$$G\ \theta,\emptyset = \frac{\mathrm{P}(\theta,\emptyset)}{\frac{\mathrm{Wt}}{4\pi}},$$

where $(\theta,\emptyset)$ is the power radiated per unit solid angle in the direction$(\theta,\emptyset)$ and Wt is the total radiated power.

Microstrip antennas because of the poor radiation efficiency have poor gain. Numerous researches have been conducted in various parts of the world in order to obtain high gain antennas.

3.3 Directivity

If a three dimensional antenna pattern is measured, the ratio of normalized power density at the peak of the main beam to the average power density is called the directivity.

The directivity of the antenna is given by:

$$\mathrm{D} = \frac{\mathrm{Pmax}}{\mathrm{Pav}}$$

The relation between directivity and gain can be given as:

$G = \eta$, where η is the antenna efficiency.

3.4 Bandwidth

It is defined as “The range of usable frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard.” The bandwidth can be the range of frequencies on either side of the center frequency where the antenna characteristics like input impedance, radiation pattern, beam width, polarization, side lobe level or gain, are close to those values which have been obtained at the center frequency. The bandwidth of narrow band and broadband antennas are defined as:

$$\text{BW broadband} = \frac{Fh}{\mathrm{Fl}}$$

$$\text{BW narrowband \%} = \frac{Fh-Fl}{\mathrm{Fc}}\text{x}100$$

where Fh is the upper frequency, Fl is the lower frequency and Fc is the centre frequency.

3.5 Return loss

Return loss or reflection loss is the reflection of signal power from the insertion of a device in a transmission line or optical fiber. It is expressed as ratio in dB relative to the transmitted signal power. The return loss is given by:

$$RL\ dB = 10\log\frac{Pr}{\mathrm{Pi}}$$

where Pi is the power supplied by the source and Pr is the power reflected.

If Vi is the amplitude of the incident wave and Vr that of the reflected wave, then the return loss can be expressed in terms of the reflection coefficient г as:

$$Rl = -20log|\Gamma|,$$

and the reflection coefficient Γ can be expressed as

$$Γ = \frac{Vr}{\mathrm{Vi}}$$

For an antenna to radiate effectively, the return loss should be less than$-10\ dB$.

3.6 VSWR

A standing wave in a transmission line is a wave in which the distribution of current, voltage or field strength is formed by the superimposition of two waves of same frequency propagating in opposite direction. Then the voltage along the line produces a series of nodes and antinodes at fixed positions.

If (z) represents the total voltage on the line then

$$V(z) = V^{+}e^{-j\mathrm{\beta z}} + V^{-e^{+j\mathrm{\beta z}}}$$

Then the Voltage Standing Wave Ratio (VSWR) can be defined as:

$$VSWR = \frac{Vmax}{Vmin} = \frac{1+|Γ|}{1-|Γ|}$$

The value of VSWR should be between 1 and 2 for efficient performance of an antenna.

Chapter 4

Triple Band Microstrip Patch Antenna

4.1 Introduction

In this chapter, a compact triple-band microstrip slot antenna is proposed for WLAN and WiMAX applications. The antenna consists of a microstrip feed line, a substrate, and a ground plane on which some simple slots are etched. The rectangular and trapezoid slots are able to achieve dual frequencies and also provide a broadband operation at high frequency. The additional resonant mode is excited with the use of a pair of symmetrical horizontal strips embedded in the rectangular slot. Compared to the other antennas, the proposed antenna in this letter not only achieves triple bands simultaneously, but also has a rather simple structure that is easy to fabricate. Meanwhile, the measured results represent that the antenna shows a good multiband characteristic to satisfy the requirement of WLAN in the 2.4/5.2/5.8-GHz bands and WiMAX in the 2.5/3.5/5.5-GHz bands. Details of the antenna design are described in the letter, and both simulated and measured results are presented. The measured results show good agreement with the simulated ones.

4.2 Design for the propose antenna

The proposed antenna may be considered as a transformer of the slot antenna. As shown in Fig. 4.1 the configuration of the triple-band slot antenna is designed and fabricated on a substrate with FR4, relative permittivity of 4.4, and a loss tangent of 0.02. the entire size of the antenna is only 35x30x1.6 mm^3.

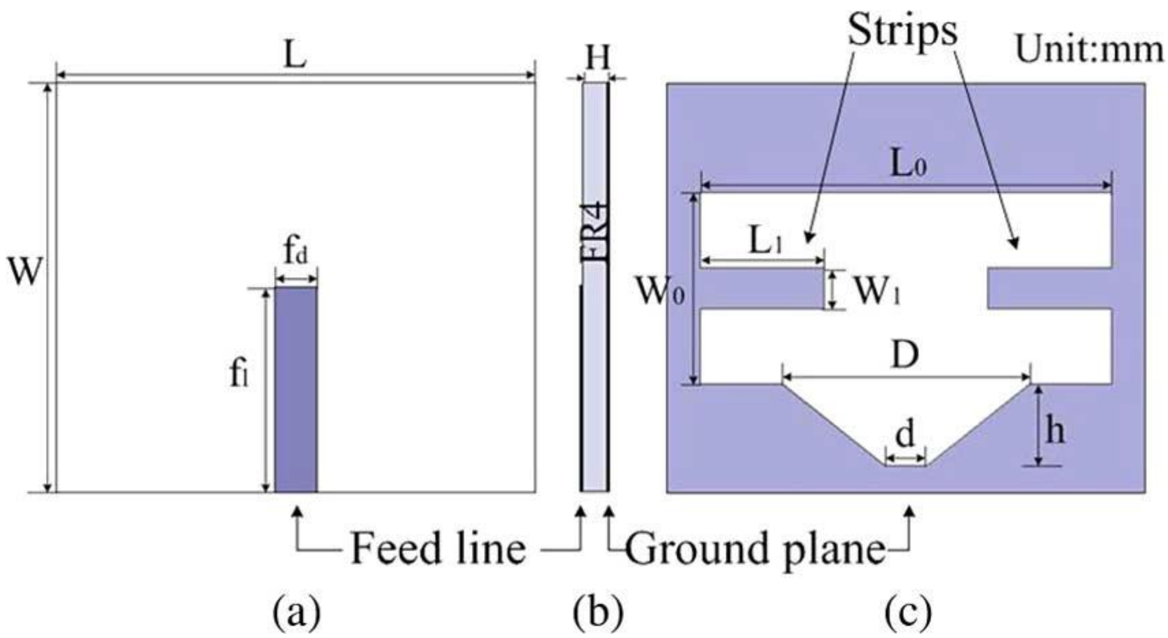


Fig. 4.1. Configuration of the proposed antenna. (a) Top. (b) Side. (c) Bottom.

Without loss of generality, a 50- microstrip feed line with a width of 3 mm is given for centrally feeding the antenna at one side of the substrate. Some simple slots are etched on the ground plane to give all the work bands. The rectangular slot can get the lowest resonant frequency. The trapezoid slot, that is a resistance gradual changing structure, givess the highest resonance and makes impedance matching in a wideband range. The strips embedded in the rectangular slot are used for feeding and providing the middle work band. Defected ground structures have been introduced here. This technique is realized by etching slots in ground plane of the microwave circuit and is namely applied for the microwave filters. This technique is used for microstrip and coplanar waveguide transmission lines. These slots are designed to achieve better performance for the microwave filters and antennas, such as increasing steepness of the cut-of slop, and to increase the stop band range of the microwave filters, moreover, compact filter and antennas can also be achieved using this technique.

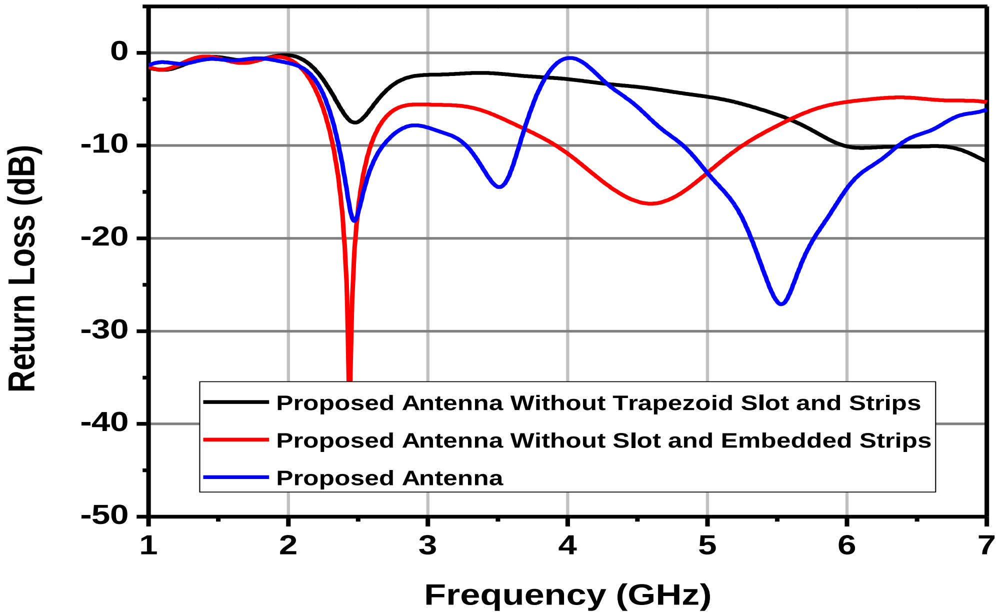


Fig. 4.2. Simulated return loss of the different structures.

The strips generates current flow path at the middle resonant frequency, which can be assumed as

$$f = \frac{c}{4L_1 . \sqrt{\varepsilon}} \qquad\qquad \varepsilon = \frac{\varepsilon_r + 1}{2}$$

where the length of the strip, is the effective dielectric constant, and is the speed of light in free space. The return loss of the different structures in the antenna design is shown in Fig. 4.2, which clearly clarifies the explanation of the proposed antenna.

By fixing optimum parameters of the proposed antenna, good impedance matching through the operating bands for the WLAN and WiMAX applications can be achieved. The photograph of the proposed antenna is shown in Fig. 4.3. The prototype of the antenna is fabricated using photolithographic printing circuit technology following the dimensions given in TABLE.4.1.

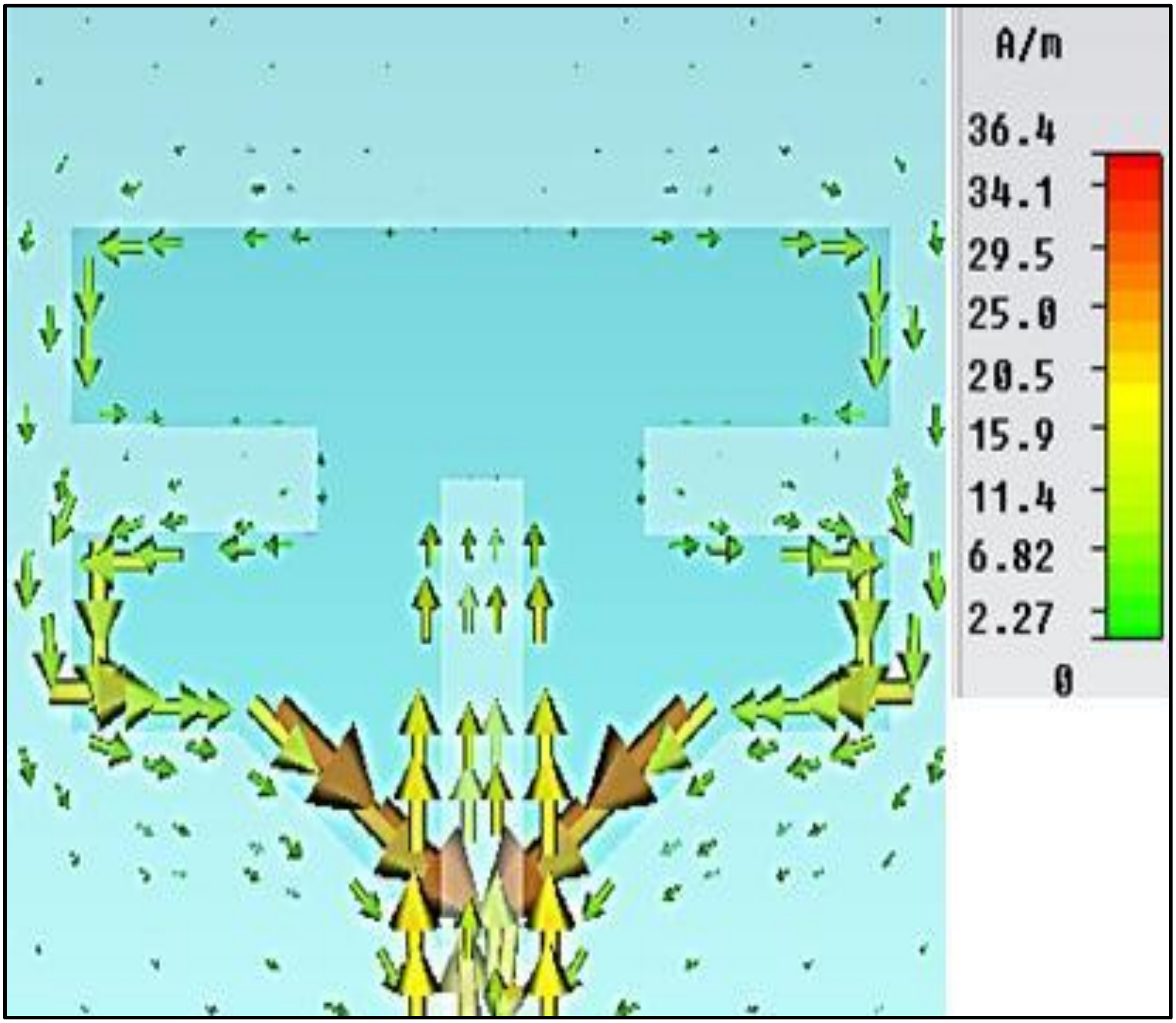
TABLE 4.1

DIMENSIONS OF THE PROPOSED ANTENNA

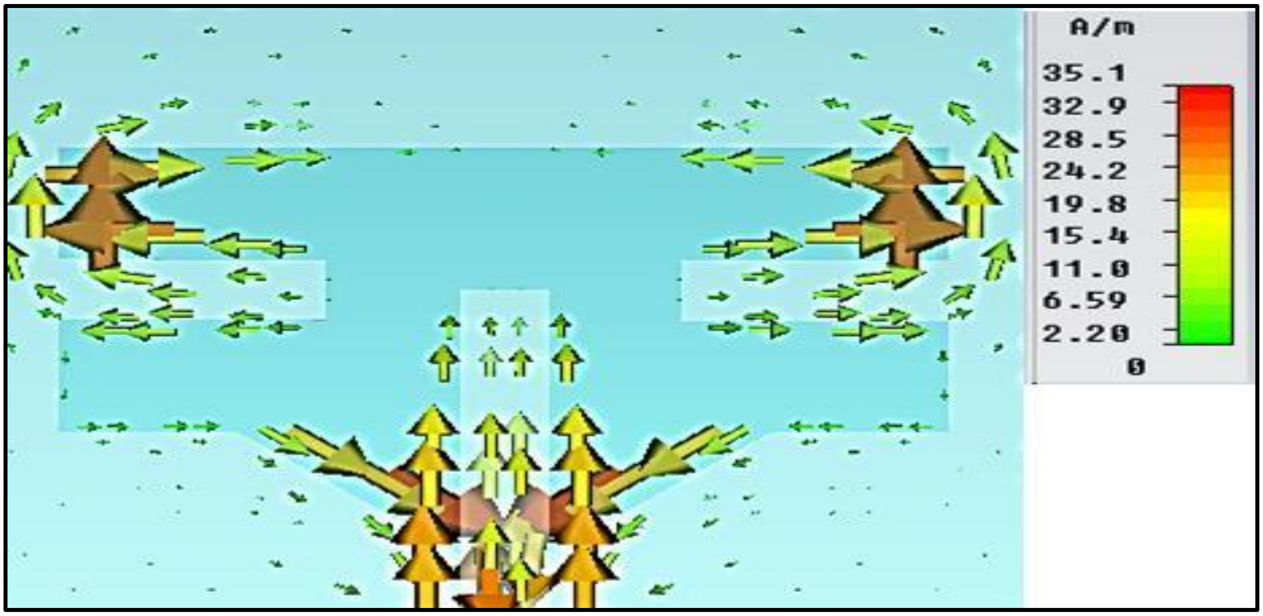
parameters	***Values(mm)***
L_1	**9**
L_0	**30**
L	**35**
W	**30**
W_0	**14**
W_1	**3**
f_1	**15**
f_d	**3**
D	**18**
d	**3**
H	**1.6**
h	**6**

4.3 Result and Discussion

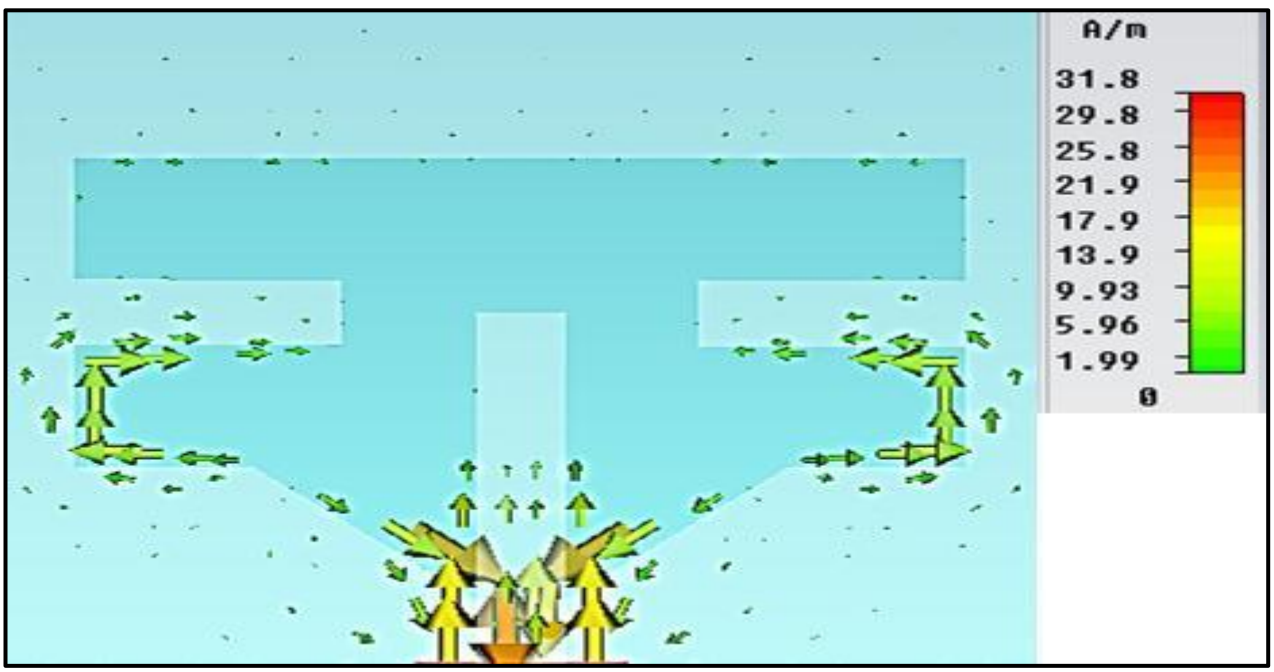
The current distribution of the proposed antenna at different frequencies are shown in the Fig. 4.3 given below



(a) 2.4 GHz.



(b)3.5 GHz.

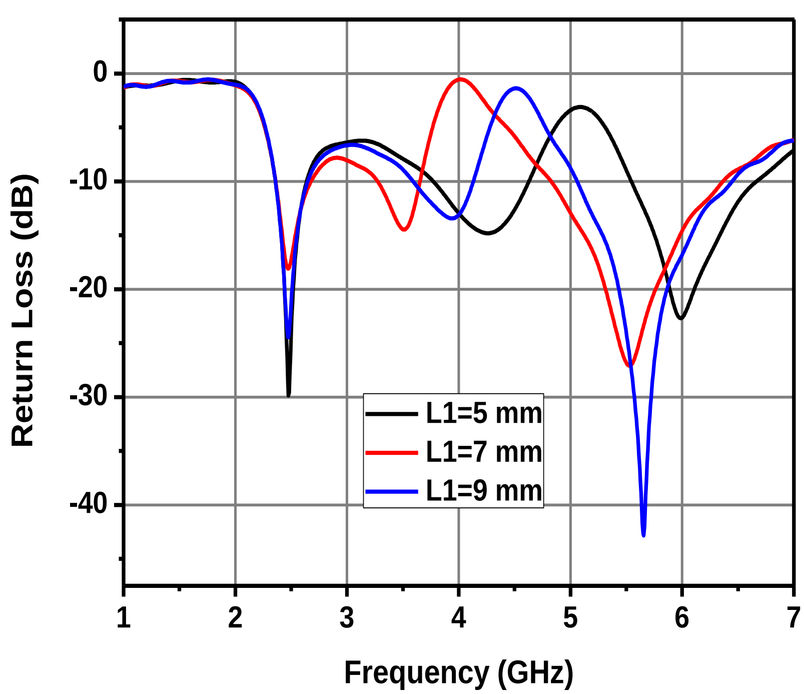


(c)5.5 GHz.

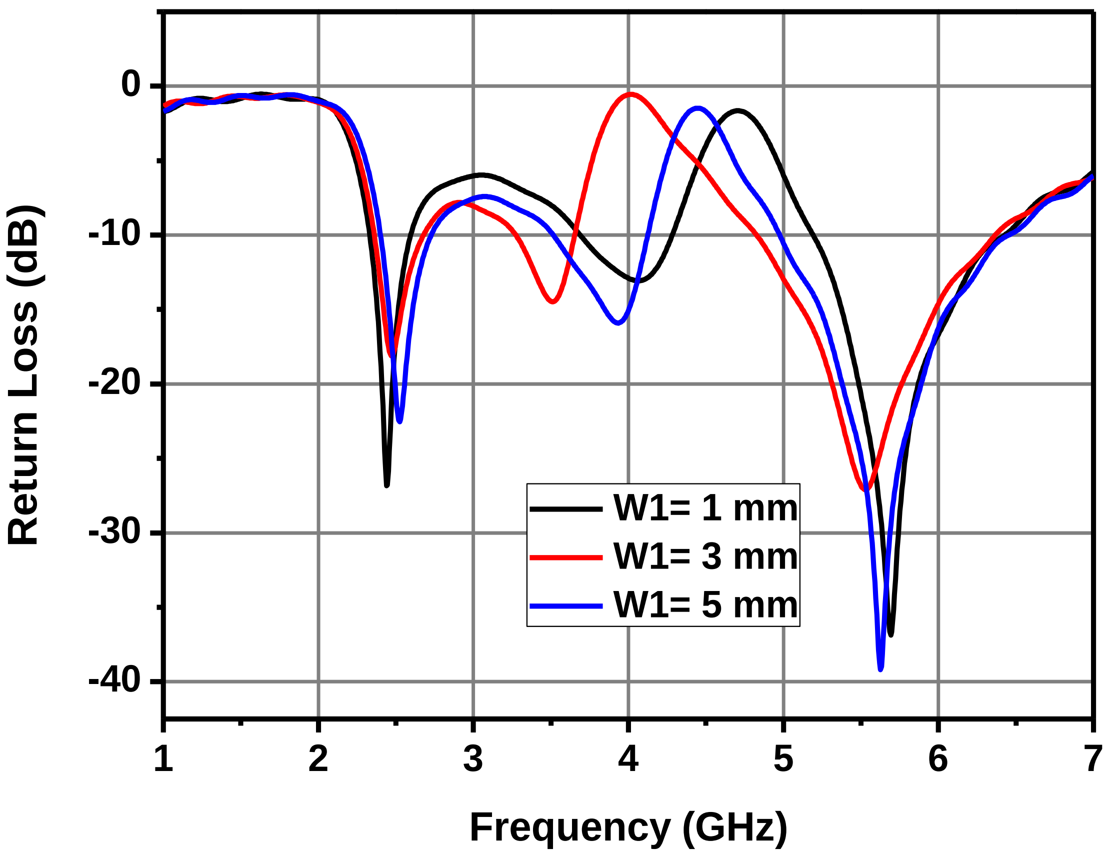
Fig. 4.3. Current distribution of proposed antenna at (a) 2.4 GHz (b) 3.5GHz (c) 5.5GHz

As frequency increases, currents are located in a smaller region of the ground plane. As shown inFig. 4.3(a), the current flows mainly along the edge of the rectangular slot. It justifies that the lowest resonant frequency is generated by etching the rectangular slot on the ground plane. In Fig. 4.3(b), the current flows along the edge of the strips upward to the upper side of the rectangular slot. Therefore, the embedded strips in the slot mainly generate the middle frequency. Similarly in Fig. 4.3(c), the current centralizes in the region nearby the trapezoid slot that generates the highest frequency.

By adding a pair of symmetrical horizontal strips to the slot, the middle frequency can be achieved. Adjusting the length and width of the strip makes changes in the domain of current distribution so that the resonance performance can be quite influenced. In Fig. 4.4, given below it can be seen that as the length of strip L_1 increases, the second and third resonances



(a)



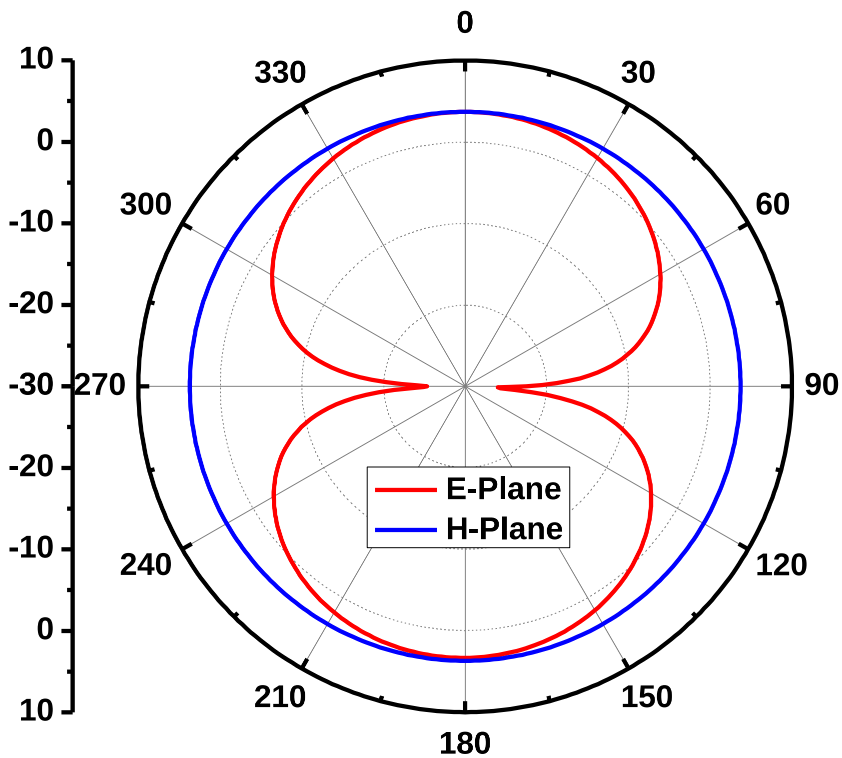
(b)

Fig. 4.4. Influence of strip dimension on the antenna. (a) Effect of strip length. (b) Effect of strip width.

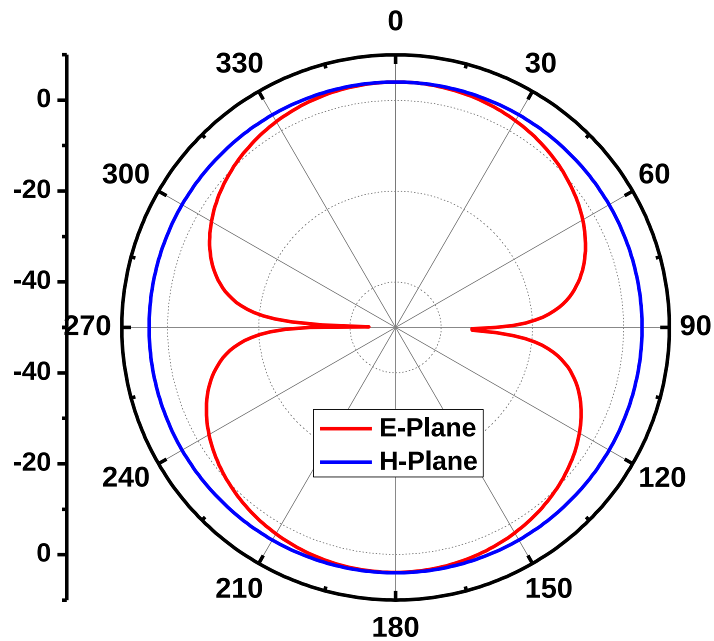
shift toward the lower side. The strip width W_1 has much effect on the return-loss characteristics apparently, and an optimum width of 3 mm is selected for achieving good impedance matching of the antenna. Similarly, the height of trapezoid slot ***h*** affects impedance matching at the highest resonant frequency, and the length of upper bottom ***D*** controls impedance matching.

4.4 Radiation pattern

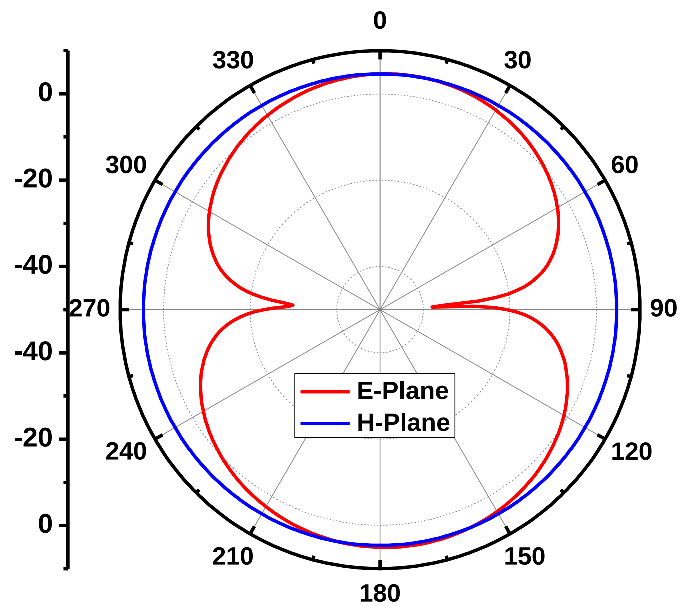
The far-field radiation patterns of the fabricated prototype at 2.5, 3.5, and 5.5 GHz, are shown in the fig. 4.5 respectively. Nearly dipole-like radiation patterns in the ***xz*** plane and omni-directional radiation patterns in the ***yz*** plane are obtained at these frequencies.



(a) Radiation pattern of proposed antenna at 2.45 GHz



(b)Radiation pattern of proposed antenna at 3.5 GHz



(c)Radiation pattern of proposed antenna at 5.5 GHz

Fig. 4.5. Radiation patterns of the proposed antenna. (a) 2.5 GHz. (b) 3.5 GHz. (a) 5.5 GHz.

4.5 Gain

Fig. 4.6 presents the peak gains in the maximum directions of each required frequency point. The antenna gain had a peakvalue of 3.86 dBi at 2.5 GHz, 3.52 dBi at 3.5 GHz, and 4.32 dBi at 5.5 GHz, respectively.

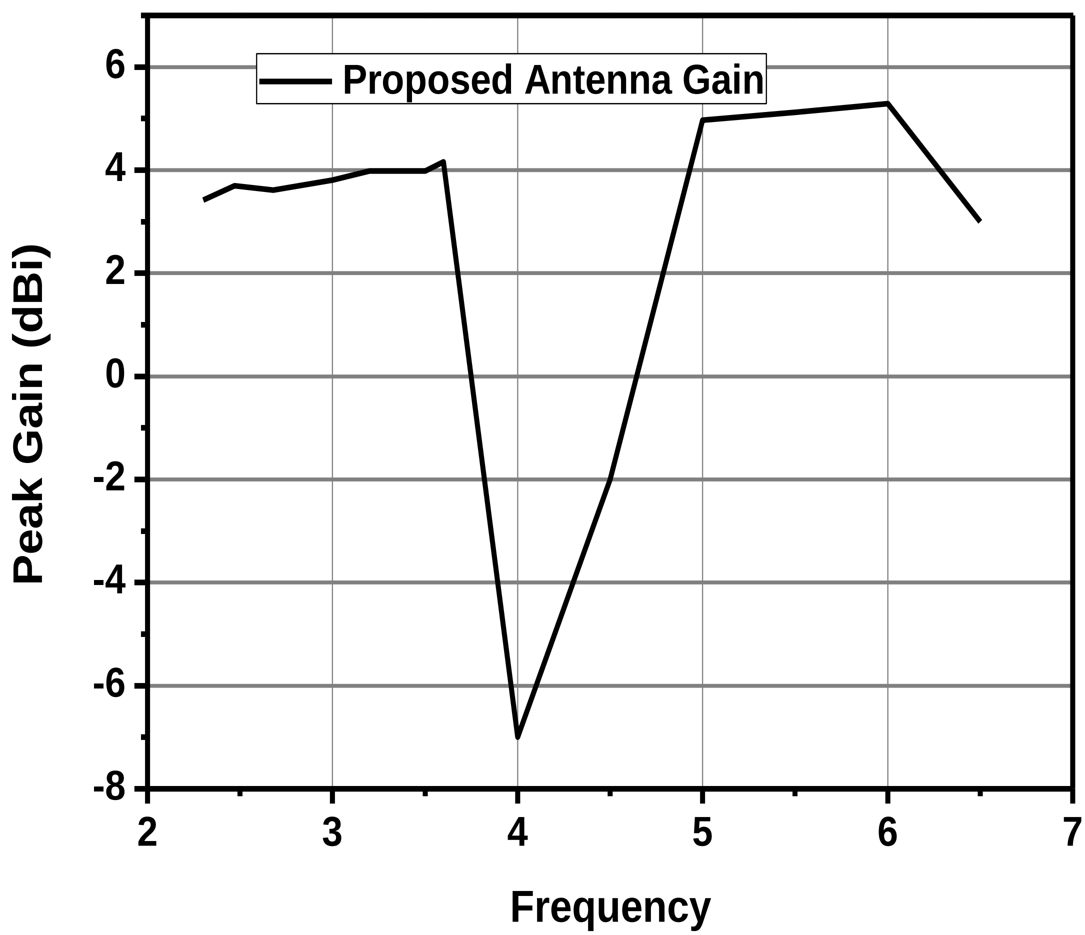


Fig. 4.6 Gains of the antenna versus different frequencies

Chapter 5

Conclusion

Conclusion

A compact triple-band slot antenna for WLAN/WiMAX applications is presented. Compared to many antennas proposed earlier, this antenna is designed based on a rather simple structure and suitable for all frequency bands of WLAN andWiMAX applications simultaneously. The proposed antenna can be considered to achieve multibands just through etching slots on the ground plane, so it can be much easier to fabricate. The measured results show that the obtained impedance bandwidths are 22.2% (2.4–3.0 GHz), 12.3% (3.25–3.68 GHz), and about 23.2% (4.9–6.2 GHz), respectively, good enough for WLAN and WiMAX applications. In addition, the proposed antenna has good radiation characteristics and gains in the three operating bands, so it can emerge as an excellent candidate for multiband generation of wireless.

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